MULTI-POSITION WORK TABLES

Field of the Invention

This invention relates generally to tables in the furniture field and, more specifically, to ergonomically designed office and industrial work stations.

The invention provides height adjustable multiple-position worktable levels producing ergonomic benefits to workers of various size while they are performing various work tasks. Research has shown that adapting a work station to the reach and viewing needs of a worker increases productivity and reduces the occurrence of injury.

The preferred embodiments of the invention are extremely economical to manufacture and readily operated by the user to achieve prompt and efficient movement of the tabletop between an infinite number of different level positions.

Mechanical and hydraulic jacks have been suggested, but they often compel the user to provide exhausting hand-cranking or careful monitoring of electrical pump controls. Moreover, such jacks introduce undesirable weight and considerable extra cost, making such jack-actuation undesirable for many users.

It is, therefore, the principal object of this invention to provide a height adjustable work surface that will move down to accommodate the smallest seated individual and then rise up to accommodate the tallest standing worker.

It is also an object of this invention to create a new height adjustable work station that will utilize a unique combination of cooperating support arms and linkages to provide greater strength and achieve a greater range of adjustment from a smaller form factor than could normally be accomplished.

It is another object of this invention that the work station is user controlled and manually operated and that the work surface adjusts quickly up and down without the use of expensive electric motors or cumbersome manual cranks.

It is a further object of this invention that the motion of the support arms and linkages is pressure assisted by a pressurized gas piston cylinder to counterbalance the weight of the tabletop.

It is a still further object of this invention that the pressure assist can be variably located to counterbalance different tabletop weights.

It is another feature of this invention that the work station provides maximum legroom for seated positions and minimum use of office space in the standing position.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The Drawings

For a fuller understanding of the nature and objects of the invention, reference should be made to the following detailed description taken in connection with the accompanying drawings(s) in which:

FIGURES 1A, 1B, 1C and 1D are successive schematic side elevation views of the first embodiment of the invention, with the tabletops shown elevated to successively greater height levels;

FIGURE 1E is an enlarged schematic side elevation view of the first embodiment, clearly showing the component parts of the mechanism;

FIGURE 1F is an exploded elevation view of the component parts of the first embodiment;

FIGURES 2A, 2B, 2C and 2D are comparable successive schematic side elevation views of the second embodiment of the invention, with the tabletops shown elevated to successively greater height levels;

FIGURE 2E is an enlarged schematic side elevation view of the second embodiment, clearly showing its component parts;

FIGURE 2F is an exploded elevation view of the component parts of the second embodiment,

FIGURES 3A, 3B, 3C, 3D, 3E and 3F are successive schematic side elevation diagrams illustrating the cooperative interaction of the human user with the first embodiment of the invention, shown in its successive raised and lowered tabletop height levels;

FIGURES 4A, 4B, 4C, 4D, 4E and 4F are successive schematic side elevation diagrams illustrating the cooperative interaction of the human user with the second embodiment of the invention showing its successive raised and lowered tabletop height levels;

FIGURES 4G, 4H, 4I and 4J are schematic side elevation diagrams of a modified version of the second embodiment. FIGURES 4G and 4I show the lowest and the highest tabletop levels of this version, and FIGURES 4H and 4J are corresponding respective lowest and highest level diagrams showing the linkage of this modified second embodiment with the tabletop removed for clarity.

FIGURE 5 is an enlarged schematic side elevation diagram of the mechanism of the second embodiment, showing the virtual centers of rotation of the tabletops rear rim and its upper support link, both positioned rearwardly in space behind the mechanism by a substantial distance.

FIGURES 6, 7 and 8 are successive schematic side elevation diagrams of the mechanism of the second embodiment, showing its component parts in its lowest, middle and highest tabletop levels.

FIGURES 6A, 7A and 8A are corresponding successive schematic side elevation diagrams of the second embodiment, showing the successive changes in the shapes of the two

parallelograms delimited by its pivot points during its transitions between height levels,

FIGURE 8 is a corresponding collection of schematic side elevation views of the same device shown in the same four different positions illustrated in FIGURES 3 and 4 as well as two additional positions 5 and 6. These diagrams of FIGURE 8 illustrate the user's manipulation of the simple controls of the worktable to move it from its lower level in position 1 toward a mid level position shown in FIGURES 2 and 3, and thence toward an upper position shown in positions 4 and 5 and finally to return it to the lower position of FIGURES 1 and 6;

FIGURES 9A and 9B are two different views of the pressurized gas cylinder valve control cable assembly incorporated in the preferred embodiments of the present invention, FIGURE 9A being a side view of the cable assembly and FIGURE 9B being a front view of the same component;

FIGURE 9C is a perspective side view of a pressurized gas spring piston-cylinder assembly;

FIGURE 9D is a schematic cross-sectional diagram of a pressurized gas spring piston-cylinder assembly, a Stabilus BLOC-O-LIFT® "gas spring";

FIGURES 10A, 10B, 10C and 10D are four comparison charts, showing operation characteristics of the device;

FIGURES 11, 12, 13 and 14 illustrate a third preferred embodiment of the invention;

FIGURE 11 is a perspective corner elevation view of this different form of the worktable in its lower position, supporting a desk top computer on its upper worktable surface;

FIGURE 12 is a corresponding view showing the same table at a higher worktable height above the height shown in FIGURE 11;

FIGURE 13 is an enlarged side perspective view of the same device in its upper position corresponding to that in FIGURE 12;

FIGURE 14 is a perspective bottom plan view of the third embodiment of the invention in which the pivoted linkage legs and the gas spring piston-cylinder are more clearly illustrated.

FIGURES 15A, 16A and 17A are successive schematic bottom plan diagrams of the elevating linkage of the third embodiment, shown respectively in the lowest, a middle and the highest positions of the tabletop height levels;

FIGURES 15B, 16B and 17B are successive side elevation diagrams of the movable legs and tabletop of the third embodiment, shown respectively in the lowest, a middle and the highest positions of the tabletop height levels,

FIGURE 18A is an enlarged bottom plan diagram of the tabletop underside portion of the elevating linkage of the third embodiment, in its highest level position shown in FIGURES 17A and 17B, with a bell crank having two equal length arms, and

FIGURE 18B is an enlarged bottom plan diagram similar to FIGURE 18A, showing a bell crank having arms of different length.

Brief Summary of the Invention

The invention comprises a method and apparatus for adjusting the height of a tabletop work surface by selecting among an infinite number of level positions.

The method for adjusting the tabletop work surface height is manually user operated and pressure assisted, whereby the user provides minimal effort to physically lift or push down the work surface to the desired tabletop height.

The invention incorporates a method and apparatus to variably locate the pressure assist device to specifically counterbalance different tabletop weights.

The apparatus is a unique combination of cooperating support arms and linkages that maintain the work surface in a horizontal position throughout its range of motion. The unique linkage provides better strength geometry than other linkage designs and pivots about virtual centers in imaginary space to create a smaller overall form factor that takes up less space in the workplace.

Best Modes for Carrying Out the Invention

The First Preferred Embodiment

In the first preferred embodiment, shown in FIGURES 1A-1E, and 3A-3F, a tabletop work surface adjusts up and down and locks in position by controlling the movement of a pressurized gas spring piston-cylinder. The tabletop **20** is supported in a horizontal position throughout its range of motion by a linkage 21, a series of articulating linkage arms pivotally mounted on a column **22** upstanding from the rear of the table base **24**. A pressurized gas spring piston-cylinder **55** is mounted between the linkage **21** and the table base **24** (FIGURE 1E). Opening and closing a valve **48** on piston-cylinder **55** (FIGURE 9A) determines the movement of the gas piston and unlocks or locks the position of the linkage.

The tabletop **20** adjusts from a low (seated) work height, FIGURES 1A and 3A to a standing work height, FIGURES 1D, 1E and 3D, to accommodate different size individuals performing various work tasks. The tabletop is adjusted manually by the user to the desired position. The amount of manual effort required to move the tabletop up and down is reduced to a minimum by the gas piston-cylinder which is pressurized to counterbalance the total weight of the tabletop and the objects on the tabletop.

First and Second Embodiments

Comparison of FIGURES 1E and 2E shows that tabletop **20** is supported in both the first and the second preferred embodiments by a pivoted linkage **21**, which itself is

pivotally mounted on column **22**, upstanding from base **24**.

In each embodiment a gas spring piston-cylinder assembly **55** has its ends pivotally connected to column **22** and to linkage **21**.

The pivotally connected components forming linkage **21** are very similar in both the first and the second preferred embodiments. This is confirmed by comparing the exploded views of FIGURE 1F and FIGURE 2F, where the various comparable components are arrayed side by side in these two FIGURES. The pivoted interconnections of each of these linkage components with the next is clearly shown in the assembled views of FIGURES 1E and 2E, and their articulated movement is shown in FIGURES 3A-3F.

Thus, for the first embodiment, a central member is the cantilever arm **29**, shown to be U-shaped in FIGURE 1F, having rear pivot point **31**, joining it to column 22, and a front pivot point **32** joining arm **29** to the underside of tabletop **20** via a top plate **33**.

A bell crank **34** is pivotally joined at a central point to the cantilever arm **29** near its front end by a pivot 36.

An upper link **37** has an upper end joined to a rear point of top plate **33** by a pivot **38**, and a lower end pivotally joined to an upper rear end of bell crank **34** by a pivot **39**.

A forward link **40** has a front end pivotally joined to the lower end of bell crank **34** by a pivot **41**, and a rear end pivotally joined to column **22** by a pivot **42** at a point substantially below pivot **31**.

Gas spring piston-cylinder **55** has its upper end pivotally joined by a pivot **54** to an upper bridge plate **56** having a rear end anchored to pivot **31** on column **22**, and a forward end anchored to a central point on cantilever arm **29**, making bridge plate **56** integral with arm **29**.

Piston-cylinder **55** also has its lower end pivotally joined by a pivot **53** to a bed plate **57** anchored to the lower end of column **22**.

The pivoting articulation of all of these pivotally connected components of linkage **21** is illustrated in the six successive diagrams of FIGURES 3A through 3F.

<u>**Pivoted Components of Second Embodiment**</u>

As shown in FIGURES 2E and 2F, the same components are connected in much the same fashion in the second preferred embodiment as they are in the first preferred embodiment, and the pivoting articulation of these components of linkage **21** is shown in the six successive diagrams of FIGURES 4A through 4F, and in FIGURES 6, 7 and 8.

Accordingly, the foregoing description of the linkage components of the first preferred embodiment is equally applicable to those of the second, and the corresponding components and pivot points have been given the same reference numerals in the FIGURES.

Cantilever arm **29** is V-shaped and bell crank **34** is generally triangular, but these do not change their function or cooperation.

<u>**Operation of the Gas Spring Piston-Cylinder**</u>

When the gas spring piston-cylinder **55** is ideally pressurized for the total weight of the tabletop, opening the control valve **48** will allow the tabletop to "float" with minimum hand pressure up and down throughout its range of motion. Closing control valve **48** locks the pressurized gas piston in its then current extension position. The amount of gas pressure is selected to counterbalance the total table weight.

The preferred pressurized gas spring piston-cylinder assembly **55** employed in the preferred embodiments of the invention is the Stabilus rigid blocking BLOC-O-LIFT® gas spring, sold by Stabilus Inc. of Gastoria, North Carolina 28052-1898. BLOC-O-LIFT® gas springs raise loads with an

accurately tuned extension force and application-specific dampening while ensuring user-friendly movement sequences. In addition, BLOC-O-LIFT® gas springs can be blocked in any position, with springing or rigid blocking in the extension or compression direction depending on the design, according to the Stabilus catalog. A schematic cross-sectional diagram of this device is shown in FIGURE 9D.

This gas piston-cylinder assembly counterbalances the weight of the table near the midpoint of its range of levels, and the rigid blocking BLOC-O-LIFT® gas spring can be blocked in any position in its range. Variable blocking is produced by the valve **48** integrated into the piston, which separates both pressure chambers gas-tight. When valve **48** is closed, blocking the gas exchange between the two pressure chambers, the BLOC-O-LIFT® gas spring is blocked, and the table level is locked. The valve **48** closes automatically when the valve tappet is released externally.

At any point in its movement when the control valve **48** is closed, the gas spring piston-cylinder **55** is thus locked in position, converting the gas spring **55** into a rigid link between its end pivots **53** and **54**. A simple unclamping lever **26**, FIGURES 1E, 2E and 8A, controls the closing of the valve **48** via a "camera-shutter style" cable **50** to lock the tabletop in position. FIGURES 3A-3F show how the depicted user, operating the unclamping means, the release control actuator (a push button or grippable paddle lever) **26**, acting through the flexible cable **50**, locks the table in various positions or unlocks the gas piston-cylinder **55** for movement to and from various positions. The components of a typical pressurized gas piston-cylinder **55** controlled by lever **26** are depicted in FIGURE 9D.

Variable (lift) Pressure Assistance From Fixed Pressure Counterbalancing Spring

The gas springs or air spring piston-cylinder assemblies of this invention are lockable at any one of an

infinite number of piston extension positions. The somewhat similar gas-charged trunk lid lifters or hood lifters for automobiles move the lid or hood up slowly to its uppermost position counterbalancing its weight. The user's manual closing of the trunk lid or hood adds a few extra pounds of force to the actual weight, overcoming the counterbalancing and slowly lowering the lid or hood to its lowest closed position.

Such lifters cannot be locked in any intermediate position.

The piston-cylinder assemblies **55** of this invention are designed to move the tabletop **20** buoyantly to a floating position, in the mid region of its raising or lowering range, when the lever **26** is actuated to unlock assembly **55**. While lever **26** is actuated the user can slowly raise or lower the tabletop **20** to any selected new position by applying slight upward lifting or downward force, making its level adjustment easy by minimizing the adjustment force required.

Actuator **26** may be located on the underside of the tabletop at a central position under its front rim, as in FIGURE 14, but it is preferable to require both of the user's hands, by positioning lever **26** under the side rims near the front rim of the tabletop **20** or **61**, as indicated in FIGURES 1E, 2E, 4A-4F, 15A, 16A, 17A, 18A and 18B.

Levers **26** are essential to tabletop movement because engaging the control lever **26** to release the locking valve **48** requires the user's hands to be in contact with the table, gripping the front portions of both side rims.

Thus, if the table were to rise or fall at a speed or direction where the user were to fear losing control, the user could simply release his grip on the control lever **26** or even remove his hands from the table, and the table would automatically lock and stop motion, a "fail safe" result.

It can be appreciated that the amount of gas pressure and the tabletop weight are dependent upon each other. If a fixed gas cylinder chamber pressure were to be specified for a given tabletop weight and the total tabletop weight were to increase, the tabletop would not "float" buoyantly in the user's hand as easily --- requiring greater manual effort to raise the tabletop, and conversely less effort to lower it.

Generally the tabletop weight and the gas pressure are matched to the known use of the tabletop, i.e. as a light assembly table or as a heavier computer work station. However when the tabletop weight is purposely changed for a different task, the gas spring (with a fixed pressure) can be re-positioned to exert more or less counterbalancing force to compensate for more or less tabletop weight.

For positioning the gas pressure cylinder, preferably a Stabilus BLOC-O-LIFT® gas spring, careful consideration of force, weight and structural vectoring need be taken into consideration. When the table start position (lowest position) FIGURE 1A is below a hinge point **31** on a fixed column **22**, the table weight to be counterbalanced is less than the actual table weight as the base-column structure supports a vectored component portion of the actual weight. For instance, if the table weighing 100 pounds were positioned at 45 degrees below the hinge point, fifty percent of the weight would be born by the base-column structure **22-24**, presenting only half the weight to be counterbalanced by the gas pressure cylinder **55**. However, as the tabletop rises to a level even with the hinge point **31** the table presents its full 100-pound weight to be counterbalanced by the gas pressure cylinder **55**.

Conversely, the gas pressure cylinder counterbalancing force is not dependent on gravity - its force is directly related to its piston stroke position. Gas cylinder pressures generally will have a range of force ratios of 1.4

to 1.0 - i.e., fully compressed a gas cylinder will exert 40% greater force than when its piston is fully extended.

The weight of the table - constantly varying by the effect of gravity and structural vectoring - is opposed by a gas cylinder pressure that diminishes constantly in a linear progression. This presents problems when the designer wishes to use the linearly diminishing gas pressure to counterbalance table weights that rise and fall in relation to the effect of gravity acting on the articulated linkage **21**.

Referring now to the schematic diagrams of FIGURES 1A and 10A, a table weight of 100 pounds is positioned 30 degrees below the hinge point **31** in the lowest adjusted position of the first preferred embodiment. The gas pressure cylinder is fully compressed. Referring to FIGURE 10A, it can be seen that in this lowest position the tabletop **20** has one third of its weight supported by the base-column structure and the weight presented to be counterbalanced by the gas pressure cylinder is 66.6 pounds. The fully compressed gas pressure cylinder has 100% of its force available to lift 67% of the table weight. Thirty degrees of travel up brings the table horizontally even with the hinge point **31** (FIGURES 1B and 3A) and increases the table weight to one hundred pounds and the base-column structure contributes zero to bear weight. The gas pressure cylinder has extended 40% of its stroke and depleted its force to 60% of its potential. In viewing the chart, FIGURE 10A, while the weight has increased by 34% - the gas pressure cylinder force has decreased 40%.

If attempting to use the gas pressure cylinder **55** as a counterbalance to neutralize the effort to move the tabletop, a different relationship of gas pressure cylinder location and table position must be realized. The table is affected by its position in relation to gravity. The gas cylinder is not affected by gravity - vector forces only

affect the gas cylinder where force is shared with structure. It is important to use the structure to mechanically disadvantage the gas cylinder when the table weight is presented at a lower value and allow the gas cylinder to be less disadvantaged when the table weight increases.

Referring now to FIGURE 10B, when the table-top is located down 30 degrees as in FIGURE 10A (and one third of its weight is reduced) the gas pressure cylinder is located down 45 degrees against the same base-column structure as bears the weight of the table. When the table has rotated to 30 degrees travel and is fully horizontal at full weight, the gas pressure cylinder is 15 degrees from its neutral position - i.e. one sixth of its force is still being shared with the structure. Comparing the curves of the actual force output in FIGURES 10A and 10B, it can be seen that repositioning the gas pressure cylinder as in FIGURE 10B has caused the force to be more equal to the table weight in the beginning of travel and to become greater in the latter portions of travel. Changing the mount points and pressure amount of the gas pressure cylinder compared to the known position and weight of the tabletop can effectively determine how the table will rise and descend as influenced by the gas pressure cylinder.

Fine Tuning the Counterbalancing Force

Turning now to FIGURE 10C, tabletop **20** starts from its lowest position (FIGURE 1A) down 30 degrees from hinge point **31**. The fully compressed gas spring **55** is pivotally joined to linkage **21** at 40 degrees below "neutral", producing gas spring force exceeding the component of tabletop weight to be counterbalanced over the entire range of tabletop level positions.

As shown in FIGURE 10D, fine tuning the compressed gas spring pivot mounting on the linkage **21** by reducing 40 degrees below neutral down to 35 degrees below "neutral"

brings the excess gas spring counterbalancing force even closer to the component of tabletop weight to be counterbalanced over the range of tabletop positions.

As the linkage **21** articulates, moving through the positions of FIGURES 4A through 4C, the gas piston-cylinder **55** becomes longer as the piston extends from the cylinder. As seen in these FIGURES and in FIGURE 2E, moving end **54** pivoted to cantilever arm **29** at 54B, describes an arc about rear pivot point 31 on column **22**.

When the axis of piston-cylinder **55**, from pivot point **53** to pivot point **54**, is at 90° to the radius of that arc, from pivot point **54** to rear pivot point **31**, this corresponds to the "neutral" tabletop level, where the components of tabletop and cargo total weight to be counterbalanced is maximum.

If the fully compressed piston-cylinder's moving end pivoted at 54B defines a radius to pivot point **31** angularly rotated below the neutral radius by 35°, substantially as suggested by FIGURE 2A, the gas spring's maximum counterbalancing force is disadvantaged until the neutral tabletop level is reached, producing the optimum match of weight to counterbalancing force shown in the diagram of FIGURE 10D..

Alternative pivot bores where gas spring terminal pivots can be mounted are shown as bores **53** and **53A**, **54** and **54A** in FIGURES 1E, 1F, 2E and 2F. Selection among these alternatives allows the user to achieve the fine tuning 2E desired.

A diagram of the neutral position of a gas piston-cylinder **52** appears in FIGURE 18A. There, moving end **48** of the piston-cylinder, guided by the outer arm of the bell crank **69**, describes an arc **67** about the central pivot **79** of bell crank **69**. A line drawn from the piston-cylinder's fixed end pivot **82** (on the underside **67** of tabletop **61**) is tangent to arc **67** at a point **68**, where radius **68-79** is

perpendicular to line **68-82**, which nearly coincides with the central axis of gas spring **52**. Radius **68-79** thus represents the neutral position of the Bloc-O-Lift in FIGURE 18A, and the acute angle 37.5° between radius **79-48** and neutral radius **79-68** indicates an angle greater than the 90° neutral position. The angles 30° and 45° in FIGURE 10B, angles 30° and 40° in FIGURE 10C, and angles 30° and 35° in FIGURE 10D all represent radii whose angles are deducted from the 90° angle of the neutral radius, before the piston-cylinder has extended to the neutral position. If the moving end 48 of the piston rod is below neutral by 30° or 45°, this reduces the moment arm of the counterbalancing force, thus disadvantaging the gas spring.

Upright Gas Piston-Cylinder and Linkage Location Points

The gas piston-cylinder **55** fixed-end and moving-end mount pivot points s **53, 53A, 54, 54A** and the corresponding linkage and table base-column mount or pivot points are carefully positioned in relationship to each other.

Referring now to FIGURE 2B, a height adjustable table representing the second preferred embodiment of the present invention and adjusted with the cantilever arm **29** in a horizontal position, with its two terminal pivot points **31** and **32** on the same horizontal plane. It can be seen in FIGURES 2B, 2E, 5, 7 and 8 that the moving-end **54** of the upright gas piston-cylinder **55** is mounted to the cantilever linkage arm **29**, and the fixed-end **53** of the gas piston-cylinder **55** is mounted to the table column **22**. In FIGURE 2E the moving-end **54** of the gas piston **55** is mounted to the linkage arm at point **54B** at a specific distance from the pivot point **31** to exert 100% effort to raise a tabletop weight. To reduce the lifting force of the gas piston-cylinder **55**, as shown in FIGURES 2E and 2F, the moving-end **54** can be repositioned at a lesser distance from pivot point **31** at location **54A** producing a decreased mechanical advantage.

Altering the mechanical advantage can be best understood by force-ratios. In FIGURE 2B, if the distance between the pivot point **31** and the table pivot point **32** were 12" and the weight on the tabletop were 10 pounds, the cantilever support arm **29** would be holding 10 foot pounds when in a horizontal position. If the moving-end **54** of the gas piston-cylinder **55** were located at a distance of 6" - the lifting force requirement of the pressurized gas piston-cylinder from half the distance would be doubled (a 2 to 1 force-ratio) requiring 20 foot pounds of piston lifting pressure.

Referring now to FIGURE 2E, if the moving-end **54** of the gas piston **55** were further relocated, and the distance were now reduced to 3" from the pivot point **31**, the lifting force of the pressurized gas piston-cylinder (attempting to lift the same 10 pounds from now one quarter the distance) would be a 4 to 1 force-ratio - requiring 40 foot pounds of pressure.

However, gas pressurized pistons have a fixed gas pressure so when the gas piston (pressurized to lift 20 pounds as in FIGURE 1E) is repositioned, the same (fixed lifting pressure) piston can only lift 20 pounds - not the required 40 pounds. Since the piston pressure is fixed, the only way the piston could lift the tabletop would be if table weight were reduced from 10 pounds to 5 pounds.

Hence it can be appreciated that the gas piston-cylinder **55** (with a fixed lifting pressure) can be positioned and repositioned at an increased or decreased mechanical advantage to compensate for increasing and decreasing total tabletop weights.

Further to the method of relocation of the gas piston mount points, the lift characteristics of the gas piston can be fine-tuned by addressing what portion of the existing stroke is utilized. Referring again to FIGURE 1E, to the extent that the gas piston fixed-end **54** is moved inwards

towards the pivot point **31** and the fixed-end mount point **53** remains the same, the gas piston moves through a correspondingly shorter stroke distance to lift the linkage via the cantilever arm through the same range of motion.

Depending upon the distance from the moving-end **54** to where the fixed-end **53** is relocated to the table column **22**, e.g. at mount point **53A** (FIGURE 1E), which is further, or point **53** (FIGURES 1E and 1F), which is closer, the stroke portion utilized will be determined to be at the beginning of piston travel (when the piston exerts the greatest force) or at the mid or end of its piston travel (when the piston exerts correspondingly less force). Hence it can be further appreciated that a gas piston of any given fixed pressure (when repositioned closer to the pivot point) has a shorter stroke requirement. By locating the fixed-end at differing length locations to use different portions of the stroke, it can effectively adjust the lifting power characteristics of the gas piston stroke to also relate to varying total tabletop weights.

It can be lastly appreciated that instead of a number of different gas piston mount points on the table base and linkage arms, a sliding mount mechanism (or other means to variably locate the two mount points) can be utilized.

Forwardly Projecting Air Spring Piston-Cylinder

In FIGURES 4G, 4H, 4I and 4J, a modified second embodiment of the invention is shown, with the substantially upright air spring piston-cylinder **55** replaced by a forwardly projecting air spring piston-cylinder assembly **51**. Piston-cylinder **51** is also preferably a Stabilus Block-O-Lift locking gas spring, having end points **53** and **54** for mounting it to the other linkage components (FIGURES 9C, 9D, 4G-4J).

In FIGURES 4G and 4H, at the lowest level position of the tabletop **20**, forwardly projecting air spring **51** is

tilted downward, among the compactly associated components of linkage **21**.

In FIGURES 4I and 4J, at the highest level position of tabletop **20**, the extended gas spring **51** has pivoted upward to tilt upwardly, with its end points **53** and **54** respectively pivotally connected to the column **22** and to the cantilever arm **29**, still positioned among the compactly associated components of linkage **21**.

It can be understood from FIGURES 4G to 4J that the location and operation of the gas pressure piston-cylinders are unrelated to their orientation in relation to gravity, but they are still relatively affected by structural vectoring. A forwardly projecting near-horizontally positioned gas spring **51** is mounted in the second preferred embodiment, to produce the same range of motion and neutral buoyancy lift force as compared to the upright and near vertical gas springs **55**.

In addition, when FIGURES 4G-4J are compared to FIGURES 6-8, for example, the absence of the upright gas spring **55** and its replacement by the forwardly extending gas spring **51** among the other components of linkage **21** creates a more streamlined and efficient column **22**, with all of the linkage **21** including gas spring **51** forming a single articulating assembly directly under the tabletop.

Gas spring piston-cylinder assemblies **51** and **55** perform similar functions with efficiency, and both provide the same opportunities for fine tuning their counterbalancing force, as illustrated in FIGURES 10C and 10D.

Tabletop Parallelogram Support

A traditional "four-bar parallel arm system" creating a tabletop support link parallelogram defined by pivot points **32-38-39-36** is shown in FIGURES 6B, 7B and 8B. This four-bar parallelogram holds the tabletop **20** in a horizontal position, as the linkage **21** moves through its range of

positions, locked by gas spring **55** whenever the unclamping lever **26** is not actuated.

A second four-bar parallelogram **31-36-41-42** guides the motion of linkage **21**. Both of these four-bar parallelograms are shown in FIGURES 6A, 7A, 8A, where they are all shown to be unskewed or unflattened over the operating range of linkage **21**, and their acute angles remain greater than 45 degrees throughout this range, assuring effective counterbalancing force transmission over the continuous range of tabletop height levels.

In fact, this system may be viewed as a "six-bar system", in which the six bars are the rigid cantilever arm **29**, defining line **31-32**; rigid bell crank **34** defining line **37-36-41**; forward link **40**; upper link **37**; an imaginary line **31-VCP** (an imaginary virtual center pivot point in space) positioned substantially rearward behind the mechanism; and another-imaginary line **VCP-38**, both imaginary lines and point VCP being shown in FIGURE 1E and 2E.

Imaginary line **31-VCP** is parallel to line **32-38** joining the two pivot points supporting the tabletop **20**. Imaginary line **VCP-38** is parallel to line **31-32**, joining the two terminal pivot points of cantilever arm **29**.

Two additional virtual center pivot points are shown in FIGURE 5: VCP_L, the virtual pivot point for the rotation of the uppermost linkage pivot point **38**;and VCP_T, the virtual pivot point for the rear rim of tabletop **20**.

The presence of these imaginary virtual center pivot points VCP, VCP_L, and VCP_T, all substantially rearwardly behind column **22**, base **24** and tabletop **20**, produces an extremely compact mechanism with an unusually small form factor. This allows the mechanism to be backed up to the wall of a room, with no tangible components protruding behind it.

Multiple Linkages

It will be readily understood that wherever one single column **22** and linkage **21** assembly is employed, it may be quite sufficient to counterbalance a small tabletop. Most wider tabletops will be more stable at all selected levels if they are supported by two column **22**- linkage **21** assemblies. Indeed, three or more parallel linkage-column assemblies may be useful for supporting extra-wide tabletops. However, all such multiple column-linkage assemblies should be governed by a single unclamping lever **26**, actuated by a single human user. If two levers **26** are employed on opposite front corners of the tabletop, they should preferably be ganged together, particularly when one central BLOC-O-LIFT° ("BOL") is installed. This produces "light" counterbalancing of lighter cargo loads. If two columns **22** are installed, each may have its own gas spring piston-cylinder **55**, providing "heavy duty" counterbalancing of heavier loads. If each air spring **55** has its own lever **26**, actuating either lever will unlock only one air spring, and the table will not be free to move until both levers **26** are actuated.

A third option provides "super heavy duty" counterbalancing of much heavier loads, and employs three gas spring units, which should all be unlocked ideally by a ganged pair of levers **26**.

Gas Spring Piston-Cylinders Without Clamping

In other applications it may be desirable to use a gas pressure spring without clamping means having the same force characteristics as the Stabilus BLOCK-O-LIFT. Uncontrolled extension gas pressure springs also made by Stabilus are referred to as NON BLOCKING LIFT-O-MAT gas springs for lifting, lowering, moving, and adjusting table structures. On these occasions, the first or second preferred embodiment is utilized without the user unclamping the gas spring for raising or lowering and whereby the gas spring could be

mounted for automatic full rise or mid position buoyancy. A raised linkage system with tabletop could rise like an elevator to reach a shelf where a box container could be placed on the tabletop, which would automatically lower to mid or full down position as a result of the weight of the box container. A worker loader located below could remove the box container from the tabletop, and with the weight removed the tabletop would return to its buoyant position or to a fully raised position to be re-loaded with another box container.

Without a user controlled locking device, the concern has been expressed that the tabletop under the force of the gas spring could "snap" up to the raised position, but the dynamic damping characteristics inherent to Stabilus gas springs can be employed to slow the linear motion of the tabletop so as to not create a motion speed danger.

The Third Preferred Embodiment

The third preferred embodiment of the invention relates to the office furniture field and more specifically to ergonomically designed computer desks and work stations, including adjustable height computer training tables for school classrooms.

Extensive computer use has recently produced wide recognition of the importance of good ergonomic practices that increase productivity and reduce the occurrence of injury. At the heart of these practices is the adaptation of the work station to the size of the individual to promote proper work posture.

Most desks are basically stationary and do not move to accommodate the various sizes and shapes of individuals. Carpal tunnel syndrome, posture problems and other maladies are all caused by poor positioning of computer components in relation to the human user, who may be sitting for long periods of time and doing repetitive tasks.

The emphasis today is to fit the desk surface to the computer user. Today's computer users come in all ages and sizes and desks need to adjust to each individual user. To date, industry has responded with adjustable height keyboard platforms and monitor stands. There are also work stations that are adjusted incrementally (during assembly) to fit one desk to one user - they are not dynamically adjustable. There are now also adjustable height desks that rise and fall with crank handles or electric motors. These solutions are cumbersome and expensive.

Adjustable seats that keep the user's feet flat on the floor, keyboards at elbow height to reduce carpal tunnel repetitive stress, monitors high enough and far enough away to reduce neck and eye strain, etc are prevalent today. However, this is achieved by adding components such as adjustable keyboard trays to existing writing style desks of fixed height which are most often too high for today's computer use. Smaller females and taller males work in compromised postures causing fatigue. Even when the computer components are properly positioned all the other work tools such as the mouse; telephone, adding machines, etc. are still out of proper reach.

The opportunity is to create a height adjustable desk surface that moves both the keyboard and monitor and everything else on the desk together in a quick and easy motion. This would address the sitting needs of any one individual user - but further, it is important to address the multiple shift work segments where computer work stations are shared by a number of different size individuals. Hence the work station should adapt to any one individual and to the range of sizes of all the other individuals in the workplace as it moves up or down to accommodate different sitting positions.

Height adjustment is important beyond the office - recent concern has been directed at the growing number of school children being trained to use computers in the classroom. These students are seen sitting on high chairs trying to reach the desktop with legs dangling and neck straining to see the monitor. On average five students share a computer in U.S. classrooms - with the computer desk level fixed and each student struggling to adapt themselves to see and use the keyboards and monitors.

With this third preferred embodiment, illustrated in FIGURES 11, 12, 13, 14, and 15A through 18B, a unique desk is achieved that adjusts to the sitting height and reach of all size people. In this design the entire desktop surface raises and lowers in a dynamic fashion. To allow ease of adjustment a counterbalancing force compensates for the weight of the desk top and the computer and other components so the desktop seemingly floats up and down when the height adjustment is unlocked by actuating an unclamping means, and then maintains that position when the unclamping means lever is released.

Therefore it is the primary object of this embodiment of the present invention to create a height adjustable work surface that will conform to the proper posture requirements of children and adults.

It is a further object of the present embodiment to have the work surface level adjustable with relative ease so that its height can be quickly changed in a simple fashion.

It is a further object that the work station is manually controlled and moves quickly up and down without the use of electric motors or manual cranks.

The height adjustable work station of this embodiment of the invention utilizes a unique scissors shaped support leg assembly **60** on each side that pivots about an axle point **62** to raise and lower the desk height while maintaining the tabletop **61** in a horizontal position.

The crossed legs **63 and 73** comprising one side of the scissors legs assembly **60** have rollers or wheels attached at one end and fixed brackets at the other. The upper front end of one leg **63** is pivotally bracketed at **64** to the underside of the front edge **65** of the tabletop. The other rear end of leg **63** has a wheel **66** in contact with the floor. The other leg **73** of the same side has a roller **74** in contact with the underside **67** of the rear portion of the tabletop. On its other front end is a pivotable bracket **76** in contact with the floor. The two legs **63 and 73** are attached at center by a pivot **62** to comprise a crossed leg shaped like an "X", under each side rim **77** of the table top **61**. As the two legs pivot about the axle point **62**, a scissoring action is created which changes their relative angle and hence the height of each "X" shaped leg assembly **63-73** supporting one side of tabletop **61**.

As the angle of the two legs in relation to each other changes, it can be seen in FIGURES 15B, 16B and 17B that there is a corresponding relative distance change between the ends of the two support legs in both the horizontal and vertical directions. The two leg ends with rollers attached **66** and **74** produce the level change in tabletop **61** as they roll along the floor and the underside of the desktop. The upper fixed brackets **64** pivotally mounted to the underside **67** of the tabletop **61** and the lower brackets **76** resting on the floor remain fixed in position along their horizontal planes. When the relative change of angle occurs, the tabletop rises and descends while remaining in a horizontal position.

To control the angle between the legs, a rolling distance limiting device is connected to the rollers on the underside **67** of the tabletop. This device is an unclamping lever **26** on the underside of table **61**, preferably under its edge rim **77** near its front rim **65**. Lever **26** operatively connected by a shutter-type cable **50A** to a valve **48** at the

outermost piston end of the gas spring piston-cylinder **52**. The outermost end of the extensible piston is also pivotally connected by horizontally pivoting linkage to the rollers **74**, as shown in the upper right portion of FIGURES 15A, 16A, 17A, 18A and 18B.

As in the other embodiments, the linearly variable adjustment component is a gas filled piston-cylinder **55**, which produces a counterbalancing force to compensate for table weight. By closing the gas valve **48** (FIGURE 9A) the piston-cylinder **52** can be locked in any position along its piston stoke.

Referring now to the drawings and especially FIGURES 11, 12, 15B, 16B and 17B, there are two scissoring leg assemblies **60** of the same dimensions shown as left and right leg support systems with four floor contacts to stabilize the desk.

When legs **63** and **73** are arranged in a scissors shape, they may be connected by an axle **62** which is fastened through the two aligned center points **62**. As the legs go through the scissors action shown in FIGURES 11 to 12, and 15B, 16B and 17B, it can be seen that the fixed points and rolling points change distance relative to each other, and allow the tabletop to change height relative to the floor, while maintaining the tabletop in a fixed and rigid horizontal position. Referring now to FIGURE 14 the table or desk assembly is viewed from underneath in a perspective bottom plan view. It can be seen in FIGURE 15B that as the legs go through this scissors action, the horizontal distances increase as the legs spread and the desk lowers. The horizontal distances decrease as the legs come together in FIGURE 17B to raise the tabletop.

In FIGURE 14 and FIGURES 15A, 16A and 17A, an axle **72** is supplied connecting through the upper ends of legs **73** and mounting the rollers **74**. In order to control the rolling distance, the axle **72** is connected to the unclamping lever

26 positioned near an outer front rim 65 of tabletop 61. The roller axle 72 is pivotally connected to a horizontally pivoting bell crank lever 69, whose innermost end is pivotally connected to the linkage bar 81 at pivot 80. The bell crank lever 69 is shaped like an L and is pivotally fixed at its central point to the underside of the tabletop 61 at pivot point 79. The outer end of the lever 69 is attached to the moving mount point of a gas valve 48, shown in FIGURES 9A, 15A, 16A, and 17A, positioned at the extensible outer piston end of a counterbalance force-generating pressurized gas piston-cylinder 52. The other end of the gas cylinder 55, preferably the Stabilus BLOC-O-LIFT ®, is pivotally fixed at 82 to the underside 67 of the tabletop 61.

Referring again to FIGURE 14 and the scissors action of FIGURES 15A through 17B -- it can be seen that as the tabletop is lowered and the distance of the axle 72 from the fixed bracket 64 increases, the reversing action of the bell crank lever 69 causes the gas cylinder 52 to compress along its stroke. This compression provides the force to return the tabletop 61 upwards as the compressed gas seeks to resolve its increased stored pressure.

Upright, Forward Projecting or Horizontal Gas Springs

It will be noted that the lockable counterbalancing gas springs 51, 52 or 55 incorporated in each of the three embodiments of this invention provide the force required to counterbalance the weight of the tabletop and its cargo, in the same way causing the tabletop to float toward its buoyant mid-range level whenever the gas spring is unlocked by the user. At such times, each of the tabletops can be raised or lowered by very slight force applied to it by the user.

When the lever 26 is released by the user, the gas spring is locked, blocking the counterbalancing action and

maintaining the tabletop at the last level selected by the user.

Thus the orientation of the gas spring piston-cylinders' central axis in each embodiment does not change or affect its counterbalancing action. Upright gas springs 55 (FIGURES 1-4F, 5-8A), forward projecting gas springs 51 (FIGURES 4G-4J) and horizontally-oriented gas spring 52 (FIGURES 11-15A, 16A, 17A, 18A and 18B) are not dependent on gravity but only upon their pressurized condition to deliver their linearly varying counterbalancing force over the entire range of their full stroke length.

It will thus be seen that the objects set forth above, and those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction with departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.